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Inventor: Jakob SCHILLINGER et al.
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TRANSLATOR'S DECLARATION

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that I have, to the best of my ability, prepared the attached accurate, complete and literal translation of the German language text of:

German Priority Application 103 58 277.0,
as filed on December 11, 2003

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: January 11, 2008

Walter F. Fasse
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~~Sensortransponder und Verfahren zur Reifenaufstandslängen- und Radlastmessung~~

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Munich, the 23rd of February 2005
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~~Der Präsident~~ The President
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Sensor Transponder and Method for Measuring Tire Contact Lengths and Wheel Load

The present invention relates to a sensor transponder and a method for measuring tire contact lengths and wheel load.

Object of the invention is the simple and cost-effective calculation of the tire contact area, since as the "effective" contact area of the tire with the road, this significantly influences both the traction behavior (force transmission behavior, braking behavior) as well as the friction losses resulting from flexing. Furthermore, a suitable device for this is to be provided.

While the method proposed according to the invention for achieving this object directly determines the tire contact area, from the knowledge of the tire type, however, the tire contact area (tread footprint) can be calculated with sufficient accuracy. A further important influential value, the wheel load, can be calculated with the aid of the tire internal pressure, the temperature and the tire contact area. With the aid of the inventive sensor transponder and the special arrangement or the preferred construction thereof the corresponding data can be acquired.

In the description below, the features and details of the invention will be described in greater detail using exemplary embodiments and in connection with the appended drawings. In that regard, the features and relationships described in

individual variants also apply in principle to all exemplary embodiments. In the drawings:

Fig. 1 shows a schematic view of an arrangement of a sensor transponder according to the invention in a tire,

Fig. 2 shows a diagram in which the progression of the centrifugal acceleration dependent on the rotation angle of the tire is shown,

Fig. 3 shows five further diagrams for evaluating the signals of a sensor transponder with an acceleration sensor with low-pass behavior according to a first embodiment, and

Fig. 4 shows five diagrams for evaluating the signals of a sensor transponder with an acceleration sensor with differentiating behavior according to a second embodiment of the present invention.

According to Fig. 1, a transponder or sensor transponder 1 for measuring a tire contact length 6 and/or the wheel load is preferably secured on the inner side of a tire running surface 2. Thereby, the progression 7 of the centrifugal acceleration illustrated in Fig. 2 for a complete rotation, that is to say a rotation angle of 0° to 360°, is generated in the transponder 1.

For a sensor transponder 1 mounted on a wheel rim 3 (which is not shown in Fig. 1), the continuous progression 8 of the centrifugal acceleration shown in Fig. 2 would arise. Due to the mounting on the tire casing or the inner side of the tire running surface 2, no centrifugal acceleration 7 acts on the transponder 1 in the region of the tire contact area (an edge length of this area is provided with the reference number 6).

A countersink or sinking-in deflection 4 of the tire 2 is determined from the wheel load, the tire type (dimensions, construction, material) and the tire internal pressure. This countersink or deflection 4 results in a specific tire contact length 6.

For measuring purposes, this tire contact length 6 or also tread footprint length 6 can be determined by evaluating the centrifugal accelerations 7, 8 shown in Fig. 2. As shown in Figs. 3 and 4, for this purpose especially by means of acceleration sensors of which the time progression is detected and via a threshold and gradient evaluation, the tire contact length 6 which is relative to the full revolution can be calculated.

In the further evaluation, then the tire contact area and the wheel load can be calculated to advantage from the tire contact length 6 through reference to the or dependence on the tire pressure, the tire rotational speed and the utilized tire type.

From the comparison of these individual results (tire contact length 6, wheel load, tire contact area) for all of the tires, a conclusion can be advantageously reached regarding tire pressures that are incorrect relative to each other and/or absolutely. Furthermore, the wheel load and the tire contact length 6 can be tested against pre-specified limit values, and the exceeding of these values can be stored and, if necessary, displayed. In the further embodiment of the present invention, these informations can for example be made available to the drive train electronic system for optimizing the engine-transmission setting, to the chassis electronic system for setting the damper-spring characteristic, and to the electronic brake for adapting the brake coefficients.

The absolute (time-related) or relative (angle-related) tire contact length 6 can for example be transmitted to a super-ordinated central unit as a digital value, or as a signal (phase, frequency, amplitude or load modulation) which has been modulated onto the HF carrier. Advantageously, but not necessarily, especially there in the central unit, the comparison between the individual signals, the correction of the tire type, the temperature, the tire pressure etc. as well as the further forwarding to super-ordinated systems can be carried out.

The acceleration measurement can be carried out according to a capacitive (micromechanical, spring-mass areas), piezoresistive (micromechanical, DMS seismic mass), ferroelectric (magnetic flux change), inductive (spring-magnet induction), electrodynamic

(spring-electromagnet) or piezoelectric principle (material: in particular quartz, piezoceramic or piezofoil; procedure: in particular bending, axial, torsion or shear strain).

With measuring principles which additionally have a generatory effect, such as the piezoelectric principle for example, the acceleration energy can additionally charge up an electric buffer storage. Upon reaching sufficient energy, the measurement signals are transmitted.

The at least one acceleration sensor can additionally be used for triggering a signal transmission, since in order to reduce the load on a battery, a measurement of the tire contact length or pressure is only important or advantageous while driving. In addition, the angle position of the sensor transponder 1 can be determined, and from this knowledge an advantageous point in time for the optimum overlap of the transmission and receiving antenna(s) corresponding therewith can be determined.

In the preferred full construction stage, the sensor transponder 1 comprises especially sensors for temperature, pressure and acceleration, as well as a memory for the tire-specific parameters.

The evaluation can be conducted, for example, in the two manners described below. With a DC-capable acceleration sensor with low-pass behavior, of which the signals are shown in Fig. 3, the centrifugal acceleration 10 is detected with an acceleration

sensor (output signal 11) and is digitalized with the aid of a comparator threshold 12. Not shown in Fig. 3 are the superimposed vertical accelerations which arise from the quality of the road 5 (Fig. 1).

The output signal 13 of the comparator controls an integrator 14, which can be realized in analog technology (op-amp and/or RC elements) or digital technology (counter), and the end value of which (marked by arrows) is stored until the end of the period. With the respective positive flank of the comparator output, a further integrator 14 is started, stopped and stored. The output signal thereof represents a value for the rotation duration of the tire 9. The quotient formation of the signals 14 and 15 produce the relative tire contact length 6 relative to the tire circumference. Instead of the integrator, the rotational speed of the wheel can also be used for the calculation.

The signal evaluation of an alternative, non DC-capable acceleration sensor with differentiating behavior is represented in Fig. 4, whereby identical or similar components or signal progressions are assigned the same reference numerals. In that regard, the output signal 11 of the acceleration sensor is compared against threshold values and evaluated in a comparable or similar manner.

In connection with Fig. 1, in the following, the essential features and advantageous further embodiments of the sensor transponder 1 according to the invention will again be described.

The mounting or installation of the transponder 1 is especially carried out on the inner side of the running surface 2 of the tire 9. It comprises at least one acceleration sensor for the above described measurement of the tire contact length 6. In addition, a memory for the tire-specific parameters for calculating the tire contact area can be integrated on the sensor transponder 1. Furthermore, the transponder 1 optionally comprises a pressure sensor for monitoring the tire pressure and calculating the wheel load. In addition, a temperature sensor for temperature measurement and correction can be provided on the sensor transponder.

List of reference numerals:

1 Sensor transponder

2 Tire running surface

3 Wheel rim

4 Countersink or sinking deflection

5 Road

6 Tire contact length

7 Centrifugal acceleration
(transponder proximity running surface)

8 Centrifugal acceleration
(transponder on wheel rim)

9 Tire

10 Centrifugal acceleration

11 Output signal, acceleration sensor

12 Comparator threshold

13 Output signal, comparator

14 Integrator

15 Signal

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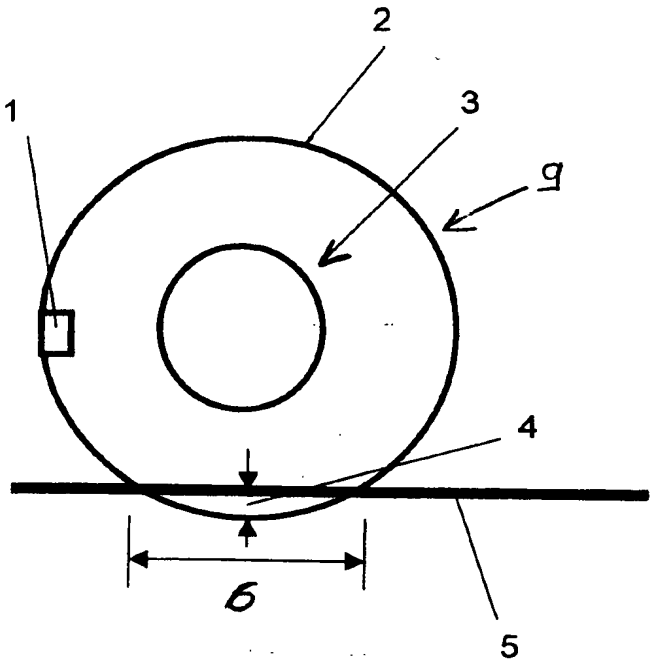
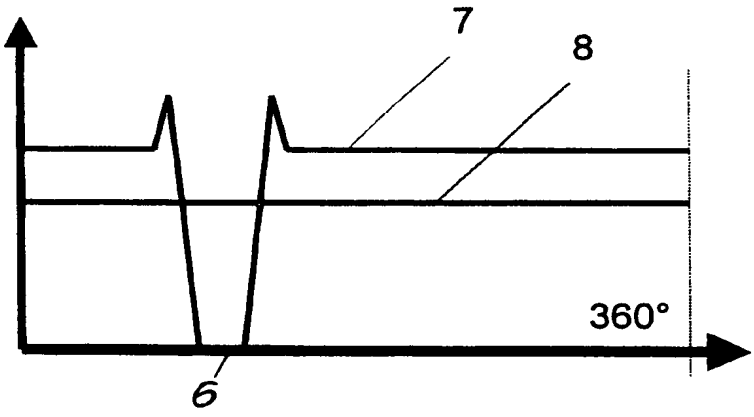


Fig. 1

~~Zentrifugalbeschleu-~~
~~nigung Transponder~~ Centrifugal Acceleration Transponder



~~Umdrehungswinkel~~ Rotation Angle

Fig. 2

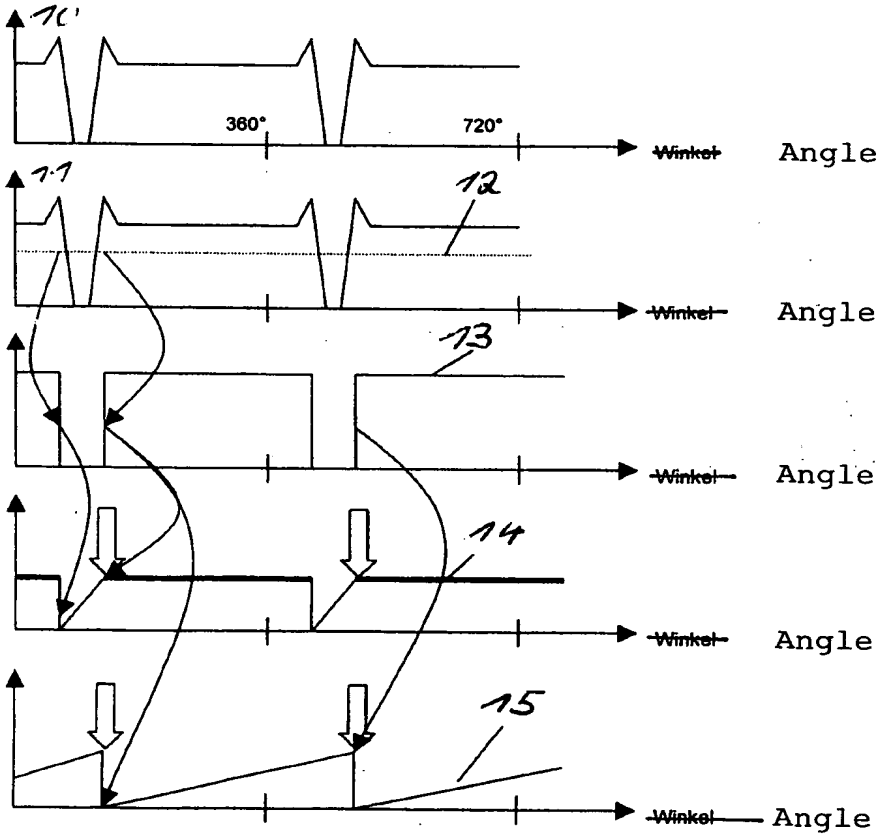

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Fig. 3

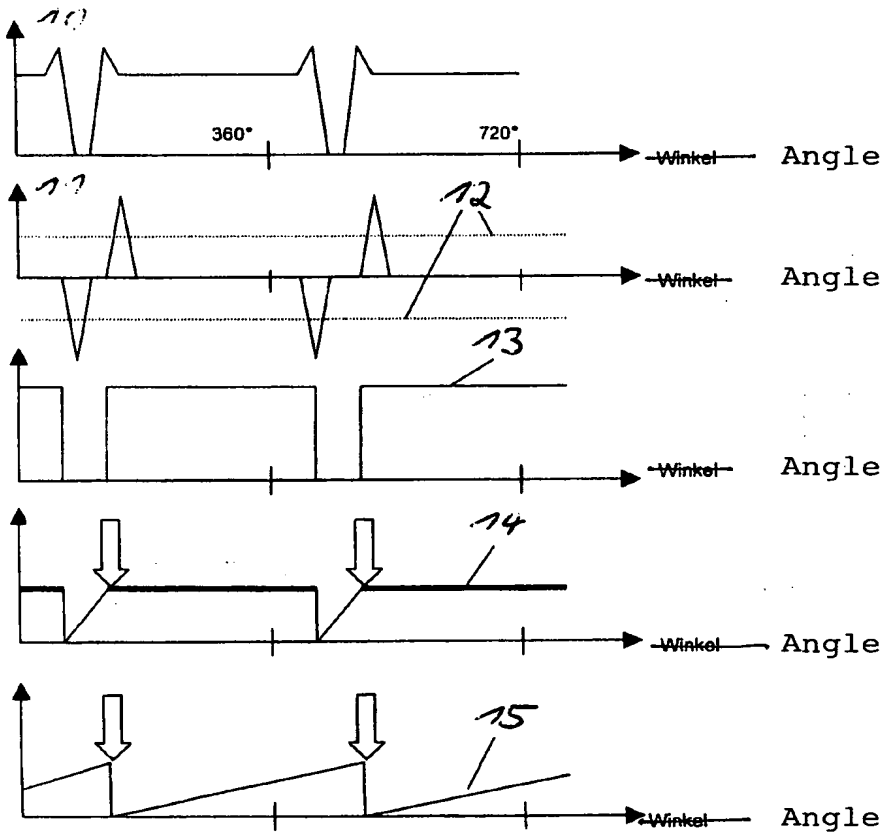
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Fig. 4